

FINAL TECHNICAL REPORT

FOR NASA GRANT NCC-3-171

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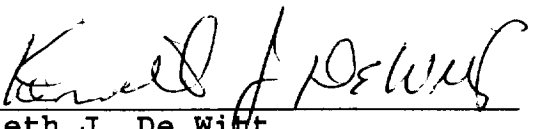
RAREFIED FLOW OF GASES IN INTERNAL AND EXTERNAL GEOMETRIES

Prepared for

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by

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The work done under this grant from NASA Lewis began in March, 1990 and was completed in September, 1995. The grant was used to support the research performed by Dr. Chan Hong Chung, a Post-Doctoral Research Associate at the University of Toledo. Dr. Chung's work was performed under my direction and involved computational codes for the flow of rarefied gases in internal and external geometries.

The attached list of publications resulting from this work are all available in the open literature, and comprise the final report for this grant. All of these publications have previously been submitted to the grant technical monitor.

PUBLICATIONS FROM WORK DONE ON GRANT NCC 3-171

Refereed Journal Articles

1. "Numerical Simulation of Rarefied Gas Flow Through a Slit," J. Thermophysics and Heat Transfer 6, No. 1, 27-35, Jan.- March, 1992, with C. H. Chung, D. R. Jeng, and T. G. Keith, Jr.
2. "Internal Structure of Shock Waves in Disparate Mass Mixtures," J. Thermophysics and Heat Transfer 7, No. 4., 742- 744, Oct.-Dec. 1993, with C. H. Chung, D. R. Jeng and P. F. Penko.
3. "Numerical Analysis of Rarefied Gas Flow Through Two-Dimensional Nozzles," J. Propulsion and Power 11, No. 1, 71-78, Jan.-Feb., 1995, with C. H. Chung, D. R. Jeng and T. G. Keith, Jr.
4. "Low-Density Nozzle Flow by the Direct Simulation Monte-Carlo and Continuum Methods," J. Propulsion and Power 11, No. 1, 64-70, Jan.-Feb., 1995, with C. H. Chung, S. C. Kim and R. M. Stubbs.
5. "Numerical Analysis of Hypersonic Low-Density Scramjet Inlet Flow," J. Spacecraft & Rockets 32, No. 1, 60-66, Jan.-Feb., 1995, with C. H. Chung, S. C. Kim and H. T. Nagamatsu.
6. "Simulation of Overexpanded Low-Density Nozzle Plume Flow", AIAA Journal 33, No. 9, Sept., 1995, with C. H. Chung, R. M. Stubbs and P. F. Penko.

Refereed Conference Papers

1. "Flow of Rarefied Gases Over Two-Dimensional Bodies," AIAA 9th Computational Fluid Dynamics Conference, Buffalo, New York, 6/89. Published in Conference Proceedings, pp. 389-399, with D. R. Jeng, C. H. Chung and T. G. Keith, Jr.
2. "Rarefied Gas Flow Through Two-Dimensional Channels," AIAA/ASME/SAE/ASEE 25th Joint Propulsion Conference, Monterey, California, 7/89, Paper No. AIAA 89-2893, 11 pgs., with C. H. Chung, D. R. Jeng and T. G. Keith, Jr.
3. "Numerical Simulation of Rarefied Gas Flow Through A Slit," AIAA/ASME 5th Joint Thermophysics and Heat Transfer Conference, Seattle, Washington, 6/90, Paper No. AIAA-90-1694, 11 pgs., with C. H. Chung, T. G. Keith, Jr., and D. R. Jeng.

4. "New Approach in Direct-Simulation of Gas Mixtures," AIAA 26th Thermophysics Conference, Honolulu, Hawaii, 6/91, Paper No. AIAA-91-1343, 7 pgs., with C. H. Chung and D. R. Jeng.
5. "Internal Structure of Shock Waves in Disparate Mass Mixtures," AIAA 30th Aerospace Sciences Meeting, Reno, Nevada, 1/92, Paper No. AIAA-92-0496, 7 pgs., with C. H. Chung, D. R. Jeng and P. F. Penko.
6. "DSMC Analysis of Species Separation in Rarefied Nozzle Flows," AIAA 27th Thermophysics Conference, Nashville, Tennessee, 7/92, Paper No. AIAA-92-2859, 9 pgs., with C. H. Chung, D. R. Jeng and P. F. Penko.
7. "FDDO and DSMC Analysis of Rarefied Gas Flow Through 2D Nozzles," AIAA 27th Thermophysics Conference, Nashville, Tennessee, 7/92, Paper No. AIAA-92-2858, 11 pgs., with C. H. Chung, D. R. Jeng and P. F. Penko.
8. "DSMC Analysis of Detailed Flow Structures in Gas Mixtures," 18th International Symposium on Rarefied Gas Dynamics, Vancouver, Canada, 7/92, with C. H. Chung and D. R. Jeng.
9. "DSMC and Continuum Analyses of Low-Density Nozzle Flow," AIAA 31st Aerospace Sciences Meeting, Reno, Nevada, 1/93, Paper No. AIAA-93-0727, 12 pgs., with C. H. Chung, S. C. Kim and R. M. Stubbs.
10. "Analysis of Plume Backflow Around a Nozzle Lip in a Nuclear Rocket", AIAA/SAE/ASME/ASEE 29th Joint Propulsion Conference, Monterey, California, 6/93, Paper No. AIAA-93-2497, 9 pgs., with C. H. Chung, S. C. Kim and R. M. Stubbs.
11. "DSMC Analysis of Hypersonic Low-Density Flows Around a Scramjet Inlet," AIAA 28th Thermophysics Conference, Orlando, Florida, 7/93, Paper No. AIAA-93-2870, 11 pgs., with C. H. Chung, S. C. Kim and H. T. Nagamatsu.
12. "Simulation of Low-Density Nozzle Plumes in Non-Zero Ambient Pressures," AIAA 32nd Aerospace Sciences Meeting, Reno, Nevada, 1/94, Paper No. AIAA-94-0357, 8 pgs., with C. H. Chung, R. M. Stubbs and P. F. Penko. Also NASA TM 106501, 1994.
13. "Effect of Ambient Pressure on Low-Density Nozzle Plumes," 33rd Aerospace Sciences Meeting, Reno, Nevada, 1/95, Paper No. AIAA-95-0411, 7 pgs., with C. H. Chung and R. M. Stubbs.